Drag Head Angles from a Bubbler

by Jerry Knisley

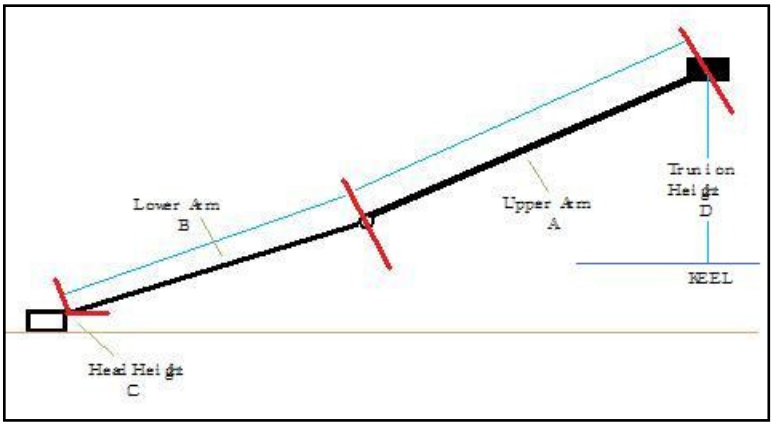
The drag arm depth of a hopper dredge is usually measured one of two ways: with bubblers (our preferred method and used on most dredges) or with angle sensors. Since the bubbler system measures pressure of the water at a depth, the angle measurement where it is taken is independent of the angle of the drag arm to which it is attached. The difficulty of using angle sensors is that they are more susceptible to the motion of the vessel than the bubbler system.

Recently a project arose that involved a hopper dredge with both bubblers and angle sensors were installed. The systems worked independently of each other and could be compared to verify the depth of the drag head. The bubbler system had been installed on this particular dredge for well over 10 years. It is, therefore, the default trusted system due to years of reliable service. As part of my recent visit to the dredge, we determined to compute the angles of the drag arms based solely on the bubbler system and compare the measurements to the angle sensors.

We realized the sensors are never going to be exactly the same due to the differences in relative accuracies and measurement methods. Also, no angle is available from the bubbler when the drag head is out of the water because of the bubbler mechanism itself.

Calibration of Bubbler Systems

The math used for the bubbler is 'simple trigonometry'. The only tricky part of it is making sure that the Forward Draft is taken into account.



Below is an excerpt from the driver code.

```
double ht = pt - info.fwd_draft;

double a = ht + D1;

double c = L1;

upA = asin(a/c)*180/M_PI;

a = D2-D1;

c = L2;
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loA = asin(a/c)*180/M_PI;

gimA = upA – loA

Where:

L1 is the length of the upper arm

L2 is the length of the lower arm

D1 is the depth of the Gimbal

D2 is the depth of the Drag Head

pt is the trunnion height

M_PI is pi (3.14159265)

gimA is the Gimbal Angle (0 is a straight pipe)

upA is the Upper Angle

loA is the Lower Angle (approach angle)

Note: Angles are relative to horizontal.

When referring to the arm of the dredge, it is good to understand the terminology. The arm of a dredge is very much like the human arm.

Trunnion The point at which the arm attaches to the dredge. Much like the human shoulder joint, this is the point that rotates the arm up and down.

Gimbal The first articulation point below the trunnion. The gimbal is much like the human elbow except that it can bend in both directions.

There is a point known as the 'critical angle'. It is calculated using two other angle measurements:

- The angle of the trunnion from horizontal (upA)
- The angle of the gimbal from horizontal (gimA)

Critical Angle = upA - gimA

If the critical angle exceeds 16 degrees the arm breaks. When the dredge operates, the critical angle should be as close to zero as possible. The straighter the pipe, the less resistance there is to the flow.

Drag Head The point that impacts the bottom and extracts the material. This would be analogous to the wrist in the human arm.

Knowing the length of each section of the arm is critical when computing the depth and position of the drag head. On my recent trip, we verified all of the dredge arm lengths for accuracy.

Calibration of Angle Sensors

The angle sensors that are used on many dredges are made by US Digital. Using their software for calibration makes the calibration procedure quite easy to follow.

Tools:

- SEI Explorer Software
- Digital Level (Available at Home Depot)
- Radio communication to Bridge

Digital Level

Procedure:

While the dredge is in calm water and the drag arms are on deck, do the following:

1. Position a crew member in the bridge at the drag tenders computer.
    a. Start the SEI Explorer software.
    b. Verify that the sensors are all available.
2. Position the second crew member on the deck near the Drag Arm.
    a. Establish communication with the bridge.
    b. Turn on the digital level and place it on the arm in line with the direction of the pipe.
    c. Allow the reading to stabilize and report this to the bridge.
3. The Bridge Crew Member should then enter the value from on deck into the SEI Software for the appropriate sensor. A negative reading should be subtracted from 360 and entered as a positive number.
4. Repeat this procedure for all of the remaining angle sensors.
5. When all arms are completed, turn off the SEI Explorer software and start DREDGEPACK®.

Conclusion

Once the system was calibrated, we compared the angles from the angle sensors to those of the bubbler system using the equations above. The angles were within 1 degree of the computed angles at all of the points we checked.

Save the Turtles!!!

The angles are not only used to determine the position of the drag arm. In many dredge areas they must closely watch Sea Turtles. An attachment to the drag head prevents the dredge from killing a turtle.

When the approach angle of the drag head with this attachment (which happens to equal the gimbal angle) is correct, the attachment plows through the upper layer of material ahead of the drag head, moving the turtle harmlessly out of the way.

With the addition of angle sensors and the bubbler equations above, the dredge now has multiple methods of ensuring that the turtle guard is at the proper angle.

The following Deflector Design information is from http://www.saj.usace.army.mil/pd/specs.htm *where more information is available.*

"The leading edge of the deflector shall be designed to have a plowing effect of at least 6" depth when the drag head is being operated. Appropriate instrumentation or indicator shall be used and kept in proper calibration to insure the critical 'approach angle'.

(Information Only Note: The design 'approach angle' or the angle of lower drag head pipe relative to the average sediment plane is very important to the proper operation of a deflector. If the lower drag head pipe angle in actual dredging conditions varies tremendously from the design angle of approach used in the development of the deflector, the 6-inch plowing effect does not occur. Therefore, every effort should be made to insure this design "approach angle" is maintained with the lower drag pipe.)"